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Original research article

DYNAMIC STABILITY AS MEASURED BY TIME TO STABILIZATION DOES NOT RELATE TO CHANGE-OF-DIRECTION SPEED

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Abstract. *Numerous physical capacities have been said to contribute to change-of-direction speed (CODS), including technique, strength, power, and dynamic stability. Out of these capacities, the relationship dynamic stability has with CODS has received very little analysis in the literature. Therefore, this study analyzed whether time to stabilization (TTS) as a dynamic stability assessment could differentiate between faster (n = 13) and slower (n = 13) recreational male team sport athletes in the 505 CODS test, and the modified T-test. TTS was measured via a force plate as the duration for the vertical force component to reach and stay within 5% of the participant's body weight following a unilateral vertical jump landing for each leg. Between-leg TTS differences were also derived. A one-way analysis of variance (p < 0.05) determined significant differences in TTS and the CODS tests; effect sizes (d) were also calculated. Pearson's correlations (p < 0.05) were calculated from the pooled data (N = 26) in order to ascertain relationships between TTS, and 505 and modified T-test performance. Results indicated the faster group were quicker in all CODS tests (p ≤ 0.001-0.042; d = 0.85-2.84). There were no differences in TTS (p = 0.071-0.961). Additionally, there were no significant correlations between TTS and the CODS tests (p = 0.138-0.963). TTS does*

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not differentiate between athletes with faster or slower CODS, nor does it correlate with 505 and modified T-test performance. Coaches wishing to assess dynamic stability relating to team sport-specific performance should use a different test for their athletes.

Key words: *dynamic stability, agility, cutting, multidirectional speed, unilateral jump landing*

INTRODUCTION

Dynamic postural stability is defined as the ability to maintain balance while transitioning from a dynamic to a static state (Wikstrom, Tillman, Smith, & Borsa, 2005). The maintenance of dynamic stability involves interaction from different components within an individual's neuromuscular system, including muscle proprioception, vision, and vestibular control. Monitoring dynamic stability is often advocated for clinical use, in that it can assess physical function following injury (Hertel, Miller, & Denegar, 2000). This capacity has been investigated in past research using assessments such as hop-and-holds (Myer, Ford, Brent, & Hewett, 2006), the Star Excursion Balance Test (SEBT) (Bressel, Yonker, Kras, & Heath, 2007; Lockie, Schultz, Callaghan, & Jeffriess, in press; Thorpe & Ebersole, 2008; Valovich McLeod, Armstrong, Miller, & Sauers, 2009), and the time taken to reach stabilization following a jump landing (Ebben, Vanderzanden, Wurm, & Petushek, 2010; Flanagan, Ebben, & Jensen, 2008; Ross, Guskiewicz, & Bing, 2005; Wikstrom, Powers, & Tillman, 2004). Time to stabilization (TTS) can be measured on a force plate through the assessment of ground reaction force, with a stable position defined as when the participant reaches and stays within 5% of their body weight (Ebben et al., 2010; Flanagan et al., 2008). A shorter TTS provides an indication of better dynamic stability.

TTS has typically been measured by using a modified, submaximal vertical jump. The TTS test will then involve setting 50% of a participants' maximal vertical jump as a target over a force plate. The participant jumps and reaches for the target from a set distance away from the force plate, before landing on one leg (Brown, Ross, Mynark, & Guskiewicz, 2004; Ross et al., 2005; Shaw, Gribble, & Frye, 2008; Wikstrom et al., 2004; Wikstrom et al., 2005). Following the landing, the participants must stabilize themselves as quickly as possible. This method has been used to assess ankle joint instability (Brown et al., 2004; Ross et al., 2005), ankle joint bracing (Shaw et al., 2008), and functional fatigue (Shaw et al., 2008; Wikstrom et al., 2004), in athletic populations. There is value in using TTS as a clinical measurement of dynamic stability. For example, athletes with stable ankles will tend to have lower TTS following a jumping task when compared to athletes with ankle joint instability (Brown et al., 2004; Brown & Mynark, 2007; Ross et al., 2005). Part of what contributes to a shorter TTS is how effectively an individual can decelerate their body mass upon landing, before reducing any unnecessary perturbations during stance. These factors may also contribute to aspects of team sport, such as within the cutting action required for change-of-direction speed (CODS) and agility. If an athlete can more effectively decelerate their body mass upon ground impact, this may also then allow then to cut into a different direction more quickly(Spiteri, Cochrane, Hart, Haff, & Nimphius, 2013; Spiteri, Hart, & Nimphius, 2014a; Spiteri, Newton, Binetti, Hart, Sheppard, & Nimphius, 2015).

Cutting during CODS and agility-based actions involves deceleration about the stance leg, before a reacceleration in a new direction (Sacco, Takahasi, Suda, Battistella, Kavamoto, Lopes, & Vasconcelos, 2006). The key parameters for effective cutting are also indicative of CODS. This includes factors such as leg strength and power capabilities, and symmetry between the legs (Hewit, Cronin, & Hume, 2013; Sheppard & Young, 2006). Furthermore, Kovacs, Roetert, & Ellenbecker (2008) stated that dynamic stability was important for an athlete, especially when considering the deceleration component of a cut. This is because sprinting, and changing direction while sprinting, involves unilateral support, which will stress and individual's ability to maintain stability during a dynamic action. Better dynamic stability, as measured by greater functional reach within the SEBT, has been shown to relate to faster multidirectional speed (as measured by 40-meter [m] sprint, T-test, and change-of-direction and acceleration test performance) in recreational team sport athletes (Lockie et al., in press). However, TTS has not been analyzed from the viewpoint of sport-specific athletic performance. Indeed, the only current analysis of TTS from a practical sporting perspective has been in regards to investigating intensities of different plyometric exercises (hopping, squat, countermovement, and depth jumps) (Ebben et al., 2010; Flanagan et al., 2008). Given that TTS following a jump may provide an indication of how effectively an athlete can stop and stabilize their body mass, this could have application to change-of-direction and cutting ability in athletes who require these capacities in their chosen sport.

Therefore, the aim of this study was to determine the relationship between TTS, as measured via vertical jump testing, and CODS in experienced team sport athletes. CODS was assessed via the 505 CODS test with cuts from both legs, and the modified T-test with movement initiation to the left and right. Participants were differentiated, according to the total time recorded for the 505 and modified T-test conditions, into faster and slower groups. The groups were compared with regards to TTS for each leg, and differences between the legs. This demonstrated if faster athletes, during the aforementioned CODS tests, exhibited differences in TTS when compared to slower athletes. In addition, data was pooled for a correlation analysis to ascertain relationships between TTS for each leg, and differences between the legs, with 505 and modified T-test performance. It is hypothesized that faster team sport athletes will exhibit shorter TTS for each leg, and will have greater TTS symmetry between the legs. It was further hypothesized that there would be significant correlations between TTS and CODS.

METHODS

Participants

Twenty-six recreational male team sport athletes (age = 22.88 ± 4.02 years; height = 1.79 ± 0.07 m; body mass = 78.62 ± 13.26 kilograms [kg]), were recruited for this study. Participants were recruited if they: currently participated in a team sport that required CODS (e.g. soccer, basketball, rugby league, rugby union, Australian football, baseball); had a team sport training history (≥two times per week) extending over the previous year; were currently training for a team sport (≥three hours per week); maintained their normal physical activity for the duration of the study; and did not have any medical conditions compromising study participation. The study occurred within the competition season for all participants. The methodology and procedures used in this study were approved by the institutional ethics committee. All participants received a clear explanation of the study, including the risks and benefits of participation, and written informed consent was obtained prior to testing.

Procedures

Participants were assessed over two sessions, separated by one week. The first session involved the CODS tests (505 and modified T-test), while the TTS assessment occurred in the second session. Prior to data collection in the first testing session, the participant's age, height, and body mass were recorded. Height was measured barefoot using a portable stadiometer (Ecomed Trading, Seven Hills, Australia). Body mass was recorded to the nearest 0.01 kg using digital scales (Tanita Corporation, Tokyo, Japan). For the first testing session, participants completed a standardized warm-up, which consisted of 10 minutes of jogging on a treadmill at a self-selected pace, 10 minutes of dynamic stretching of the lower limbs, and progressive speed runs over the testing distances. Before testing in the second session, participants completed a warm-up adapted from previous research (Ebben & Petushek, 2010; Ebben et al., 2010). This involved 5 minutes of low-intensity cycling on a bicycle ergometer, followed by 5 minutes of dynamic stretching of the lower limbs. Participants then completed practice maximal vertical jumps, both bilaterally and unilaterally, before completing the bilateral vertical jump test, and TTS assessment. Participants wore their own athletic trainers for all tests; refrained from intensive exercise and any form of stimulant (e.g. caffeine) in the 24-hour period prior to testing; and were tested in the same order across both sessions at the same time of day.

505 Change-of-Direction (CODS) Test

The methodology for the 505 was used as per established methods(Draper & Lancaster, 1985; Gabbett, Kelly, & Sheppard, 2008; Lockie, Callaghan, & Jeffriess, 2015a; Lockie, Schultz, Jordan, Callaghan, Jeffriess, & Luczo, 2015c; Nimphius, Callaghan, Spiteri, & Lockie, in press). One timing gate (Fusion Sports, Sumner Park, Australia) was used to record time. The 505 structure is shown in Figure 1. During the warm-up, participants were allowed to familiarize themselves with the movement patterns required for the 505. Participants used a standing start with their preferred leg positioned 30 centimeters (cm) behind the start line. When ready, the participant sprinted through the timing gate to the turning line, indicated by a line marked on the laboratory floor and markers. Participants were to place either the left or right foot, depending on the trial, on or behind the turning line, before sprinting back through the gate. Three trials were recorded for turns off the left and right foot, the order of which was randomized amongst the participants. Time was measured to the nearest 0.001 seconds (s), and 3 minutes recovery time was allocated between trials. If the participant changed direction before hitting the turning point, or turned off the incorrect foot, the trial was disregarded and the participant completed another trial after the required rest period. The fastest trials when cutting off the left and right legs were used for analysis. Differences between the cutting legs for the 505 were expressed as a percentage via the formula: *(slower 505 – faster 505)/slower 505 x 100*.

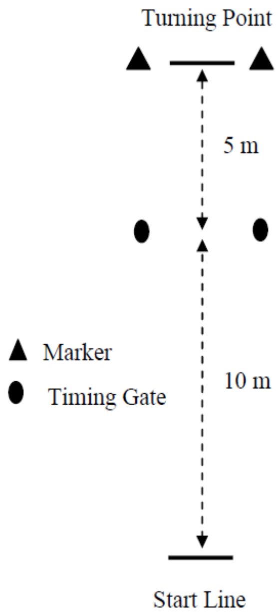

Fig 1 505 change-of-direction speed test design. m = meters

Modified T-Test

A modified T-test was used for this study (Lockie, Schultz, Callaghan, Jordan, Luczo, & Jeffriess, 2015b; Lockie et al., 2015c; Sassi, Dardouri, Yahmed, Gmada, Mahfoudhi, & Gharbi, 2009). The smaller distances between markers within this T-test assessment has been suggested to be more specific to team sport athletes (Sassi et al., 2009). Markers were positioned as shown in Figure 2, with a start line indicated by tape on the laboratory floor, and one timing gate was utilized (Fusion Sports, Sumner Park, Australia). As for the 505, participants used a standing start with their preferred leg positioned 30 cm behind the start line, and were required to face forwards at all times during the test. To start the test, participants sprinted forwards 5 m to touch the top of the middle marker. They then side-shuffled 2.5 m to the left or right, depending on the trial, to touch the next marker, side-shuffled 5 m in the opposite direction to touch the next marker, side-shuffled 2.5 m back to touch the middle marker again, before back-pedaling past the start line to finish the test. The hand that was on the same side as the shuffle direction (i.e. the right hand when shuffling to the right, and the left hand when shuffling to the left) was used to touch the marker. Participants were not to cross their feet when side-shuffling; if they did, the trial was stopped and another attempted after the required rest period. Six trials were completed in total; three with movement initiation at the middle marker to the left, and three with movement initiation to the right. The order of trials was randomized amongst the participant group. As for the 505, time was measured to the nearest 0.001 s, with 3 minutes recovery between trials. The fastest trial from each of the two modified T-test conditions was used for analysis. Differences between the modified T-test movement initiation direction were calculated as a percentage through the formula: *(slower modified T-test – faster modified T-test)/slower modified T-test x 100*.

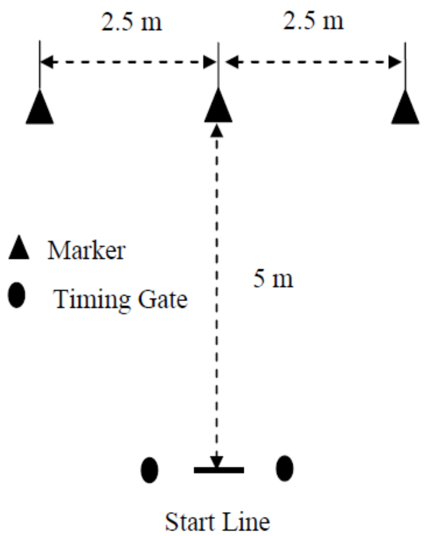

Fig 2 Modified T-test design. m = meters

Bilateral Vertical Jump Test

A Vertec apparatus (Swift Performance Equipment, Wacol, Australia) was used to measure bilateral vertical jump performance to set the target for the TTS assessment(Brown et al., 2004; Ross et al., 2005; Shaw et al., 2008; Wikstrom et al., 2004; Wikstrom et al., 2005). The participant initially stood side-on to the Vertec (on the participants' dominant side), and while keeping their heels on the floor, reached upward as high as possible, fully elevating the shoulder to displace as many vanes as possible. The last vane moved became the zero reference. The vertical jump involved the participant then jumping as high as possible using a two-foot take-off, with no preparatory step, and height was recorded in cm from highest vane moved. No restrictions were placed on range of motion during the countermovement phase of the jump. Vertical jump height was calculated by subtracting the standing reach height from the jump height. Participants completed three trials, and the average was used to calculate the target used for the TTS assessment.

Time to Stabilization (TTS) Test

Following the maximal vertical jump assessment, participants rested for 5 minutes prior to completing the TTS tests. A force platform (Kistler, Winterthur, Switzerland) that was set within the laboratory floor was used to record each jump landing. Data sampling was set at 1000 Hertz. Prior to data collection, the participant's static body weight was recorded on the force plate. The vertical jump test was then completed using established methods (Brown et al., 2004; Ross et al., 2005; Shaw et al., 2008; Wikstrom et al., 2004; Wikstrom et al., 2005). To begin the TTS test, participants stood 70 cm away from the center of the force plate. Tape was placed on the laboratory floor to indicate the take-off point. The TTS test involved a two-foot take-off and one-foot landing. Participants were provided with a 3-s verbal countdown before commencing their jump, and they were instructed to reach up and touch a vane on the Vertec stand which indicated 50% of their average maximum vertical jump, before landing on the force plate. The participant was to 'stick' the landing on the test leg, stabilize as quickly as possible, and remain motionless for 20 s with their hands placed on their hips, and head looking forwards (Brown et al., 2004; Ross et al., 2005; Shaw et al., 2008; Wikstrom et al., 2004; Wikstrom et al., 2005). If the non-landing leg touched the ground during the landing or stabilizing process, or there was excessive swaying of the non-landing leg, arms, or trunk, the trial was disregarded and the participant was re-tested. Excessive swaying was practically defined as enough sway so that the participant all but over-balanced off the force plate (Wikstrom et al., 2005). Participants were provided with approximately 2 minutes recovery between trials (Ebben & Petushek, 2010). Participants completed six successful jump tests in total (three landings each on the left and right legs). The order of which leg was tested first was randomized amongst the sample.

The ground reaction force data recorded by the force plate was analyzed using Bioware software (Bioware Software Data Acquisition, Winterthur, Switzerland). TTS was measured from the force-time record of the landing when the vertical force component reached and stayed within 5% of the participant's body weight for a 1-s duration, minus the time of landing (Ebben et al., 2010; Flanagan et al., 2008). The time of landing was identified from the vertical force trace. TTS was calculated from all trials for the left and right legs, and the average was used for analysis. Asymmetries between the legs for TTS were expressed as a percentage through the formula: *(longer TTS – shorter TTS)/longer TTS x 100*.

Statistical analyses

Statistical analyses were processed using the Statistics Package for Social Sciences (Version 20.0; IBM Corporation, New York, USA). Descriptive statistics (mean ± standard deviation [SD]; 95% confidence intervals [CI]) were used to provide the profile for each measured parameter. Participants were ranked according to total time from the speed tests (left-leg 505 time + right-leg 505 time + left modified T-test time + right modified T-test time). Following this, participants were median split into a faster ($n = 13$) and slower ($n = 13$) groups. The Levene statistic was used to determine homogeneity of variance of the data. A one-way analysis of variance (ANOVA) ensured there were no significant differences in age, height, or body mass between the groups. A one-way ANOVA also determined any significant differences between the groups in each of the CODS test variables, left- and right-leg TTS, and between-leg differences in TTS. Statistical significance for all analyses was set at $p < 0.05$. Effect sizes (d) were also calculated for the between-leg comparisons, where the difference between the means was divided by the pooled standard deviations (Cohen, 1988). For the purpose of this research, a d that was less than 0.20 was considered a trivial effect; 0.20 to 0.59 a small effect; 0.60 to 1.19 a moderate effect; 1.20 to 1.99 a large effect; 2.00 to 3.99 a very large effect; and 4.00 and above an extremely large effect (Hopkins, 2004).

Data for all participants was pooled for a Pearson's correlation analysis ($p < 0.05$), which was used to define relationships between the TTS measurements, and 505 and modified T-test. The strength of the correlation coefficient (r) was designated a descriptor as per Hopkins (2009). For this study, an r value between 0 to 0.30, or 0 to -0.30, was considered small; 0.31 to 0.49, or -0.31 to -0.49, moderate; 0.50 to 0.69, or -0.50 to -0.69, large; 0.70 to 0.89, or -0.70 to -0.89, very large; and 0.90 to 1.00, or -0.90 to -1.00, near perfect for predicting relationships.

RESULTS

There were no significant differences in age (faster = 23.08 ± 3.45 years; slower = 22.69 ± 4.66 years; $p = 0.813$; $d = 0.10$), height (faster = 1.80 ± 0.06 m; slower = 1.78 ± 0.07 m; $p = 0.404$; $d = 0.31$), or body mass (faster = 79.38 ± 11.45 kg; slower = 77.85 ± 15.29 kg; $p = 0.774$; $d = 0.11$) between the faster and slower groups. The descriptive data for the CODS and TTS variables is shown in Table 1. The faster group was significantly quicker in each CODS test conditions, by 3% and 4% in the left- and right-leg 505 (moderate effects), and by 11% and 10% in the modified T-test with movement initiation to the left and right (very large effects), respectively. The faster group also had a significantly smaller between-leg difference in 505 times, which had a moderate effect. The percentage difference in T-test time with movement initiation to the left or right was not significantly different between the groups. There were no significant differences between the faster and slower groups for TTS for either the left or right legs, or the between-leg difference in TTS. The correlation data is displayed in Table 2. There were no significant correlations between the TTS assessments and CODS tests.

Table 1 Descriptive data (mean ± SD; 95% CI) for time to stabilization (TTS) for the left and right legs, the between-leg percentage (%) difference in TTS, 505 times with turns off the left and right legs, the between-leg percentage difference in 505 time, and modified T-test times with movement initiation to the left and right, and the percentage difference in modified T-test times, in faster and slower recreational team sport athletes.

	Faster (n = 13)	Slower (n = 13)	p value	d	d Strength
Left-Leg 505 (s)	2.373 ± 0.083 (2.323-2.423)	2.455 ± 0.111* (2.388-2.523)	0.042	0.85	Moderate
Right-Leg 505 (s)	2.360 ± 0.058 (2.325-2.395)	2.456 ± 0.142* (2.371-2.542)	0.033	0.89	Moderate
505 Difference (%)	1.77 ± 1.69 (0.75-2.79)	3.09 ± 1.55* (2.16-4.03)	0.049	0.81	Moderate
Modified T-test Left (s)	5.993 ± 0.241 (5.847-6.138)	6.710 ± 0.278* (6.542-6.878)	<0.001	2.76	Very Large
Modified T-test Right (s)	6.012 ± 0.228 (5.874-6.150)	6.667 ± 0.233* (6.526-6.808)	<0.001	2.84	Very Large
T-test Difference (%)	2.34 ± 1.85 (1.16-3.52)	1.71 ± 1.47 (0.822.60)	0.361	0.36	Small
Left-Leg TTS (s)	1.053 ± 0.260 (0.896-1.210)	1.243 ± 0.427 (0.985-1.501)	0.184	0.54	Small
Right-Leg TTS (s)	1.337 ± 0.432 (0.876-1.398)	1.140 ± 0.374 (0.914-1.366)	0.985	0.01	Trivial
TTS Difference (%)	16.56 ± 15.00 (7.50-25.62)	18.27 ± 18.54 (7.07-29.47)	0.798	0.10	Trivial

p = significance; d = effect size; s = seconds

* Significantly ($p < 0.05$) different from the faster group

Table 2 Pearson's correlations between time to stabilization (TTS) for the left and right legs, and the between-leg percentage (%) difference in TTS, with 505 times with turns off the left and right legs, the between-leg percentage difference in 505 time, modified T-test times with movement initiation to the left and right, and the percentage difference in modified T-test times, in recreational team sport athletes (n = 26).

		Left-Leg TTS	Right-Leg TTS	TTS Difference
Left-Leg 505	r	0.251	0.026	0.069
	p	0.215	0.898	0.737
Right-Leg 505	r	0.322	-0.188	0.254
	p	0.108	0.357	0.211
505 Difference	r	0.178	0.012	0.027
	p	0.385	0.954	0.894
Modified T-test Left	r	0.217	0.040	0.040
	p	0.287	0.846	0.846
Modified T-test Right	r	0.322	0.088	-0.051
	p	0.108	0.670	0.805
T-test Difference	r	0.010	0.360	-0.085
	p	0.961	0.071	0.678

r = correlation coefficient; p = significance

Discussion

TTS provides a measure of dynamic stability for each leg. The faster an individual can decelerate and control their body mass upon landing from a jump, the better the dynamic stability. In a clinical setting, TTS has been used to assess joint instability, especially pertaining to the ankle (Brown et al., 2004; Ross et al., 2005; Shaw et al., 2008). However, this was the first study to analyze TTS and its relationship to team sport-specific performance in CODS tests (505 and modified T-test). The results from this study indicated that TTS did not differentiate between faster and slower recreational male team sport athletes. Furthermore, there were no significant correlations between TTS and performance in the 505 and modified T-test. This illustrated that there was no apparent relationship between dynamic stability as measured by TTS, and CODS. Nevertheless, it is important to discuss why TTS as a dynamic stability measure did not relate to CODS.

The faster participants from this study were comparable in the 505 to experienced rugby league players (~2.38 s) (Gabbett et al., 2008), as well as faster in the modified T-test when compared to male athletes from football, basketball, volleyball, and handball (6.19 ± 0.35 s) (Sassi et al., 2009). This provides an indication that the characteristics of the faster group would be similar to quicker athletes from other team sports. When compared to the slower group, the faster group was quicker in both the 505 and modified T-test, with very large effects evident for the differences in modified T-test performance (Table 1). The faster participants also demonstrated greater symmetry when cutting from the left and right legs in the 505, with a significantly lower between-leg difference of

1.77 ± 1.69%, when compared to the slower group (between-leg 505 difference = 3.09 ± 1.55%). Given that the faster group also had greater symmetry in 505 test performance when cutting off each leg, in addition to an overall better profile of CODS as measured within this study, it could be theorized that there was greater balance in the dynamic stability characteristics for each leg in the faster group. However, this was not shown by the TTS data drawn from this research, which is contrary to the study hypothesis.

TTS did not differentiate between the faster and slower groups (Table 1). In addition, even with a significant between-leg difference in 505 times, there were no significant differences between the groups for the asymmetry in TTS for the left and right legs (Table 1). Although dynamic stability has been stated to be a contributor to the ability to decelerate effectively (Kovacs et al., 2008), the lack of relationship between TTS and CODS in this study may relate to the movements required in the different assessment tasks. A cut requires deceleration to slow the body before the direction change (Sacco et al., 2006); however, this occurs over a very short time period. For example, a side-step cut in male European handball players has a stance duration of approximately 0.25-0.30 s (Bencke, Naesborg, Simonsen, & Klausen, 2000). During this time, the athlete will decelerate movement in one plane, and then reaccelerate into the new plane of motion. For the TTS assessment, the individual will land from the jump and stabilize over a time period of approximately 1.200 s (considering the mean of all participants for both legs), without a subsequent period of acceleration. This deceleration duration may be non-specific to cutting in team sports, in addition to the fact that no extra accelerative movement follows the stabilization period. This could be a reason why TTS could not differentiate between faster and slower team sport athletes in CODS.

This is further supported by the results indicating there were no significant correlations between TTS and CODS (Table 2). If TTS was an appropriate dynamic stability measure for CODS, it would be expected that significant correlations would result between the variables from this study. However, this was not the case. These results suggest that when assessing dynamic stability in relation to team sport-specific performance, some other type of assessment should be used instead of TTS. For example, Lockie et al. (in press) investigated the relationship between functional reach distance in the SEBT and multidirectional speed (40-m sprint, T-test, and change-of-direction and acceleration test) in male team sport athletes. Lockie et al. (in press) found that greater SEBT reach distances related to faster T-test and change-of-direction and acceleration test performance, and linked this to similarities in movement demands and muscle recruitment. Furthermore, functional strength training can improve SEBT performance in high school-aged females (Valovich McLeod et al., 2009), demonstrating the potential monitoring value of this dynamic stability assessment. For strength and conditioning coaches who incorporate dynamic stability training in their athletes' program with a view to enhancing CODS, an assessment such as the SEBT would be more valid than TTS for monitoring a change in this capacity.

There are certain limitations associated with this study that should be recognized. TTS was isolated in this study to investigate relationships with CODS. Other important factors for CODS, such as technique variables including step kinematics (Hewit et al., 2013) and stance kinetics (Spiteri et al., 2013; Spiteri et al., 2014a; Spiteri et al., 2015), leg strength (Nimphius, McGuigan, & Newton, 2010; Spiteri et al., 2013; Spiteri, Nimphius, Hart, Specos, Sheppard, & Newton, 2014b) and power (Garstecki, Latin, & Cuppett, 2004; Lockie, Callaghan, Berry, Cooke, Jordan, Luczo, & Jeffriess, 2014; Lockie, Jeffriess, Schultz, & Callaghan, 2012), and greater symmetry in leg strength and power (Lockie et al., 2014; Lockie, Schultz, Jeffriess, & Callaghan, 2012), was not assessed in this study. These factors could have been the major contributors to the CODS differences between faster and slower participants. Furthermore, other methods for assessing dynamic stability, such as the SEBT, were not investigated in this research, and this could have provided a relative comparative measure.

Nonetheless, within the context of these limitations the results from this study clearly indicate that TTS following unilateral vertical jump landings does not differentiate between faster and slower team sport athletes in the 505 and modified T-test, nor does it correlate with performance in these tests. If strength and conditioning practitioners wish to monitor any changes in dynamic stability that could result from specific training, they should use some other type of assessment, such as the SEBT. This is particularly true if the focus is on monitoring changes in dynamic stability as it pertains to improving CODS.

CONCLUSION

The results from this study indicated that TTS, as measured from a unilateral vertical jump landing, did not differentiate between faster and slower 505 and modified T-test performance in recreational male team sport athletes, nor did TTS correlate with CODS. This suggests that TTS does not relate to CODS. This was true for not only TTS for the left and right legs, but also any between-leg differences in TTS. This is not to discount the value of TTS as a clinical measurement, such as for assessing ankle stability. However, when considering a sport-specific measure such as CODS, TTS does not appear to be an appropriate evaluation. Previous research would suggest that an assessment such as the SEBT may be more valid than TTS as a dynamic stability test, as better SEBT performance relates to faster CODS (Lockie et al., in press), and can be improved with specific functional strength training (Valovich McLeod et al., 2009). For team sport coaches and strength and conditioning practitioners wishing to determine whether dynamic stability has improved in their athletes so as to benefit CODS, they should use a test such as the SEBT, and not TTS, to monitor changes in performance.

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DINAMIČKA STABILNOST MERENA VREMENOM DO STABILIZACIJE NIJE POVEZANA SA BRZINOM PROMENE SMERA KRETANJA

Smatra se da mnogobrojne fizičke sposobnosti doprinose brzini promene pravca kretanja (CODS), uključuući tehniku, snagu, i dinamičku stabilnost. Od ovih sposobnnosti, odnos koji dinamička stabilnost ostvaruje sa CODS je u malom obimu analizirana u relevantnoj literaturi. Samim tim, ovo istraživanje bavilo se analiziom pitanja da li bi vreme do stabilizacije (TTS) kao procena dinamičke stabilnosti moglo da se razlikuje između bržih (n = 13) ili sporijih (n = 13) rekreativnih sportista tokom 505 CODS testa, i modifikovanog T-testa. TTS je meren uz pomoću platforme za merenje sile kao trajanje komponente vertikalne sile kako bi se dostiglo i zadržalo 5% telesne mase ispitanika nakon doskoka posle unilateralnog skoka uvis za svaku nogu. TTS razlike između nogu su takođe izračunate. Analiza varijanse (one-way) ($p < 0.05$) utvrdila je postojanje statitički značajnih razlika u TTS i CODS testovima; uticaj efekta (d) takođe je izračunat. Pearsonova korelacija ($p < 0.05$) izračunata je za prikupljene podatke ($N = 26$) kako bi se odredili odnosi između TTS, i 505 i rezultata modifikovanog T-testa. Rezultati ukazuju na to da je brža grupa bila brža na svim CODS testovima ($p \leq 0.001$-0.042; $d = 0.85$-2.84). Nije bilo razlika između TTS ($p = 0.071$-0.961). Pored toga, nije bilo značajnih korelacije između TTS i CODS testova ($p = 0.138$-0.963). TTS se ne razlikuje između sportista sa bržim ili sporijim CODS, niti je u korelaciji sa 505 testom i učinku na modifikovanom T-testu. Treneri koji žele da procene dinamičku stabilnost koja je povezana sa učinkom u timskim sportovima trebalo bi da koriste drugačije testove za procenu sportista.

Ključne reči: *dinamička stabilnost, okretnost, brzina kretanja u više pravaca, doskok unilateralnog skoka*